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Kristopher Mills Date

Assessing the extent and determinants of fecal contamination of drinking water during transport, storage and use in the home: a cross-sectional study in Burkina Faso

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Abstract

Assessing the extent and determinants of fecal contamination of drinking water during transport, storage and use in the home: a cross-sectional study in Burkina Faso

By Kristopher Timothy Mills

Introduction: Despite major investment in Burkina Faso's infrastructure to provide safe water by building water pumps, diarrheal diseases remain a major contributor to the burden of disease. We conducted a cross-sectional study to assess fecal contamination of drinking water during collection, transport and use in the home and to assess risk factors at the household level that potentially influence the recontamination of drinking water. The aim of the study was to determine where along the supply chain fecal contamination occurs in order to identify possible interventions that could help ensure the microbiological quality of drinking water in this population.

Methods: 144 household surveys were used to collect information on household demographics and household hygiene, sanitation, and drinking water practices, including water fetching, quantity, treatment, transport, and storage. Paired water samples were collected from water sources, at households, and from the containers used to collect and transport water from the source to the home.

Results: While 82.3% (95% CI 67.0%-97.6%) of the point sources had no detectable *E. coli* colonies/100 mL, only 13.3% (95% CI 5.1%-21.5%) of households had safe water under the WHO guidelines of no detectable *E. coli* colonies/100 mL. There was a notable increase in contamination during the transportation stage in the water supply chain as only 32.7% (95% CI 23.1%-42.3%) had no detectable *E. coli* colonies/100 mL. Risk factors associated with increasing health risk of household drinking water included: storing household's storage container outside, scooping drinking water from the storage container, storage containers having small mouths, and storage containers being open.

Discussion: Based on the study's findings, there are a number of potential interventions that could help ensure the microbiological quality of drinking water in this population including improved water containers and point-of-use filtration systems.

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ABSTRACT

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INTRODUCTION

Global context

Globally diarrheal diseases remain a leading cause of mortality and morbidity. This is true particularly in children under the age of 5 where diarrheal diseases caused 499,000 deaths in 2015 (1). The burden of diarrheal disease is largest in Sub-Saharan Africa as this region has the highest mortality rates due to diarrhea (1). There are many factors, such as poor water quality, poor sanitation, poor hygiene, and poor food handling, which are known to cause acute diarrhea in children by exposing them to enteric pathogens through fecal contaminated water and food (2). By improving water, hygiene, and sanitation conditions, it is expected to reduce a child's risk of diarrhea (2). In 2015, 91% of households globally used an improved water source, however, as diarrheal mortality rates are still so high, other areas of improvement are necessary to decrease the burden of diarrheal diseases (1, 3).

Context in Burkina Faso

The same is seen in Burkina Faso, a landlocked-country of 17 million located in West Africa with Ghana and Cote D'Ivoire to the south, Mali to the northeast, Niger to the northwest, and Benin to the west (Fig. 1) (4). Despite major investment in Burkina Faso's infrastructure to provide safe water by building water pumps, diarrheal diseases remain a major contributor to the burden of disease causing 6% of deaths (4). In Burkina Faso, the 2015 diarrheal mortality rate among children under 5 was 251 per 100,000, considerably higher than the regional diarrheal mortality rate in Sub-Saharan Africa of 191.6 per 100,000 among children under 5 (1). One study, in Ouagadougou, Burkina Faso, found that rotavirus was the leading detected pathogen in patients, who were children under 5 with acute diarrhea (5). However, with the introduction of the rotavirus vaccine, it would be expected, based on the findings of this study and others, that diarrheagenic *Escherichia coli* and cryptosporidium would be the most detected pathogen (5, 6). While diarrheagenic *E. coli* can be transmitted by contaminated food, it is also considered a waterborne pathogen, like cryptosporidium (7, 8).

Several studies have shown that water consumed by rural households is usually contaminated, even when the point source is safe with no detectable *E. coli* colonies (9, 10, 11, 12). A recent study on household water contamination in Burkina Faso also found that contamination occurs at some point between the initial access point and consumption along the water supply chain (13). In 2016, Catholic Relief Services (CRS) Burkina Faso commissioned a study that was conducted by the Institute for Health Sciences Research (IRRS) to evaluate water quality in 10 villages in Bam and Sanmatenga Provinces. Findings demonstrated that despite clean source water points at all 10 villages, approximately 67% of the classroom drinking-water points, 100% of the household samples, and 97% of sampled children's individual drinking containers tested positive for the presence of at least one of the following indicators of fecal contamination: fecal streptococcus and *E. coli* (14).

Possible points of contamination

It is therefore highly probable that fecal contamination is occurring during transportation, storage, or use of the water in the home. A 2012 UNICEF study in Burkina Faso found that 68% of transport containers were contaminated with fecal matter suggesting that the transportation stage has a significant impact on the recontamination of water (13). This same study also found that contamination increases during storage with 96% of samples fecally contaminated (13). The manipulation of drinking water while collecting and transporting back to the household as well as the manipulation of the drinking water while transferring it to a storage container or retrieving it for consumption all provide potential opportunities for contamination (Fig. 2).

Hands contaminated with fecal matter are another mechanism along the fecal-oral route in which pathogens are transferred (15). Contaminated hands can transfer harmful pathogens, to food and elsewhere, continuing the spread of illness. In Burkina Faso, the common way for cleaning oneself or infant after defecation involves using one's bare hand, often times with water without soap (16). In this context, it is reasonable that hands are a dominant pathway for the spread of disease in this setting. Many studies have focused on the impact of handwashing interventions, like proper hand washing with soap, on health outcomes or have investigated the relationship between hand contamination and food contamination (15, 17, 18). These studies only mention possible other implications of hand contamination, like contaminating water, and few other studies investigated water manipulation as a mechanism for hands to contaminate drinking water specifically (19, 20).

Study questions and aim

Many communities have received awareness-raising and education interventions to understand the importance of protecting water along the supply chain, including proper hygiene practices, however, the problem persists at a significant level (13,14). This leads to the following questions: What factors or behaviors increase contamination between the point source and the point-of-consumption? What measures are households using to protect water quality, and how effective are they?

The ideal solution to protect water quality is with the introduction of a high quality, reticulated distribution system that delivers pressurized water with residual chlorine to household taps on a 24/7 basis (21). This prevents or minimizes the risk of recontamination and discourages consumption of untreated water (21). An interim solution is treatment at point-of-use to eliminate all microbial contamination. However, water-treatment products are not always available in proximity to the communities and their effectiveness is uncertain (3, 21). Where recontamination occurs largely during transportation, storage and use in the home, safe storage and other household management practices combined with handwashing may help minimize recontamination (11, 22).

Nonpathogenic *E. coli* is a World Health Organization (WHO) approved and widely accepted indicator of fecal contamination used to measure dose-effect health risk associated with contaminated drinking water (23-27). Based on the WHO criteria, risk classification is determined by the number of *E. coli* colonies in an 100 mL sample of water, which includes: <1, "very low risk"; 1–10, "low risk"; 11–100, "high risk"; >100, "very high risk" (26). Taking into account this aspect, it is advisable to know at what point in the water supply chain and what practices are associated with instances when the number of microbial colonies increase to a high level (11-100<number of colonies/100 mL) or very high level (100<number of colonies/100 mL) of risk to human health.

We conducted a cross-sectional study to assess fecal contamination of drinking water at various points along the water supply chain. This study is unique because we followed each household's drinking water from the point-of-source to the point-of-consumption. This included sampling at the source, from transport containers, from storage containers, and at point-of-consumption. Additionally, the study was designed to assess risk factors at the household level that potentially influence the recontamination of drinking water. The aim of the study was to determine where along the supply chain fecal contamination occurs in order to identify possible interventions that could help ensure the microbiological quality of drinking water in this population.

MATERIALS AND METHODS

Study setting and sample size calculation

Eighteen villages, located in the Center North and East Regions, as seen in Figure 1, participated in a cross-sectional study of the fecal contamination of drinking water collected and stored in households and the behavioral factors associated with increased levels of contamination. Village selection criteria included having a population of less than 5,000 and being located in one of the three provinces, Bam, Namentenga, and Gnagna. These provinces were pre-selected by CRS, as they are intervention zones of CRS's WASH programs, Kom Yilma and Programme Faso. Six villages were randomly selected from a list of all the administrative villages for each Province using probability proportional to size sampling. Based on the sample calculation below at an alpha of 0.05, 8 households were sampled from each village for a total of 144 households.

$$Sample\ size(n) = p(1-p)\left(\frac{Z^2}{E^2}\right) * DIFF\ ;\ 139 = 0.9(0.1)\left(\frac{1.96^2}{05^2}\right) * 1$$

Where *p* (0.9) is the estimated proportion of population with contaminated household water, *Z* (1.96) is the z-score value associate with the desired level of confidence at an alpha level of 0.05, *E* (0.05) is the acceptable error, and DEFF (1) is the estimated design effect. Based off of logistics and funding constraints, program managers at CRS and the lead investigator decided that 18 villages would participate in the study.

139/18=7.722 households per village ⟹8 households per village * 18 villages = 144 households

Household survey

The lead investigator developed a household survey designed to collect information on household demographics and household hygiene, sanitation, and drinking water practices, including water fetching, quantity, treatment, transport, and storage (12). The survey was translated into French, the national language of Burkina Faso, by the lead investigator and local CRS staff. CRS staff then transformed the survey digitally using iFormBuilder and uploaded it to CRS iPads. Due to the many local languages in Burkina Faso, the lead investigator trained the study enumerators on how to translate and conduct the survey in other common Burkinabe languages. The survey was piloted in 2 villages in Sanmatenga province to allow the enumerators to practice administering the survey and make necessary programmatic changes to the survey. The study enumerators conducted unannounced visits at each household where the female head of household was enrolled in the study after having been provided complete details of the study and giving consent. Thereafter the survey was administered.

Water sampling

During June and July 2017, samples were collected from two water sources and eight households in each village; samples were also collected from the containers used to collect and transport water from the source to the home (Fig. 3). For the source water, a village representative identified sources as being used the most for collecting drinking water by the village residents. This representative then indicated which households used the identified water sources. As it was rainy season and many households were in the fields, convenience sampling methods were used to select four households, per source, for participation in the study.

At each water source, two samples were collected by the enumerators: one in the morning and one in the evening, to control for possible fluctuations and variability in source water contamination levels. A village representative gave consent for collection of source water samples. Additionally, two samples were collected by enumerators from the transport containers of two conveniently selected individuals who came to fetch water from the water point coincidently. Participants were first provided complete details of the study and gave consent.

At each household, a single sample of household drinking water was collected by the enumerator. Household water was identified by the enumerator requesting the female head of household to retrieve water for her youngest child or, a hypothetical child, if one was not present. The enumerator then sampled whatever water was retrieved by the respondent. At every odd household, the enumerator collected additional water samples; one directly from the household storage container and a hand rinse sample. These households were analyzed separately to see whether there was a difference in water quality between the storage water and household drinking water and if so, determine if hand contamination was associated with this difference. Direct storage water samples were collected by having the respondent directly pour a sample from their storage container into a Whirl-pak bag, or when necessary, the enumerator collected the sample using a sterilized cup. At every even household, a sample was taken from the respondent's transport container after the respondent had cleaned their transport container, as they typically would, in front of the enumerator, then went to their point source, collected drinking water, and then return back to the household. The enumerator then collected a sample from the washed transport container.

Hand rinse samples

Hand rinse samples were collected at every odd household. The enumerator requested the respondent to place their right hand in a large, sterile Whirl-pak bag filled with 500 mL of a sterile water and buffer solution (28). The enumerator gently massaged the respondent's hand for 30 seconds. Hand rinse buffer solutions were prepared every morning by the lead investigator.

Sample analysis

All water samples were collected using sterile Whirl-pak bags (Nasco, Fort Atkinson, WI USA) donated by Emory University's Center for Global Safe Water. The buffer solution used for the hand rinse samples were prepared using Dulbecco's PBS 1L buffer (Caisson Laboratories Inc., UT, USA) donated by Caisson Labs and sterile water bought locally. All samples were stored in ice boxes equipped with sterilized ice-packs immediately after collection and then transported on the same day to the Center-North Regional Laboratory, run by the Ministry of Agriculture, Water Resources and Fisheries, in Kaya, Burkina Faso. All samples were analyzed for presence of *E. coli* by lab technicians at the Center-North Regional Laboratory using membrane filtration methods. Unfortunately, the laboratory's methods did not include using dilutions, but instead analyzed only full 100 mL samples. Since plates with more than 100 *E. coli* colonies were considered too numerous to count were given a level of 100 *E. coli* colonies/100 mL for the purposes of analysis. For quality assurance, a lab blank was processed using distilled water every time after 18 samples were processed.

Statistical analysis

Data analyses were conducted using SAS software, Version 9.4 of the SAS System for Windows (SAS Institute Inc., NC, USA). Household water quality estimates and logistic regression estimates were adjusted for the complex sample design. The mean colony count of the two source samples and the two transport samples were used to find a single measurement for both the source and transport stage of the water supply chain respectively. For the purposes of analytic modeling, these measurements represented the water quality of the source and transport stage of the water supply chain for households that used that particular source. For bivariate and multivariate analyses, we used ordinal logistic regression as the proportional odds assumption held. Final model selection for the multivariate model included only factors with p values of <0.10 in bivariate analysis.

Ethics

The study was reviewed and approved by the Burkina Faso Ethics Committee (No. 2017-7-0113). The study was deemed exempt by Emory University’s Institutional Review Board. Written informed consent to participation in the study was obtained by the female head of each household, a village representative, and each participating adult respondent. If respondents were illiterate or could not sign, consent forms were communicated verbally and consent was given via the respondent’s fingerprint.

RESULTS

Study population

A total of 144 households from 18 villages, all with populations of <5000 inhabitants, were enrolled in the study (Fig. 1). The villages were selected population proportional to size from 9 districts, 3 from each of the regions of interest. There were no refusals on the village or household levels, however, one village, Nafo, was substituted for the village, Sam, due to Sam being inaccessible during the raining season. Nafo and Sam are located 10 km from each other and have relatively similar populations, 2,209 and 2,822 respectively. Additionally, 27 households were excluded from the analysis due to the household's water source being a well and not a pump (n=24), having incomplete data (n=3), or samples were compromised during transport to the lab facility (n=4). The majority of the respondents were female, 98.3%, 77.8% of the head of households had no formal education, and 86.1% of the households' primary source of income came from farming. Household and community demographics can be found in Table 1.

Water supply chain

A total of 497 water samples were collected from the 18 villages. 144 household drinking water samples were collected at each of the 144 households. In all villages, two sources were sampled, one collected in the morning and the other in the afternoon, except in the case of five sources in which only one sample was collected and in the case of one source where three samples were collected. A total of 74 source samples were collected. Similarly, 70 transport containers were sampled at the villages' sources. Two transport container samples were collected at each point source, one collected in the morning and the other in the afternoon, except in the case of two sources in which only one sample was collected and in the case of two sources where three samples were collected.

At every even households (n=72), a direct sample was taken from the household's storage container by directly pouring a sample from the container into a Whirl-pak bag, or when necessary, collecting the sample using a sterilized cup and then transferring it into a Whirl-pak bag. At these same households, except in four households where materials were not available, a hand rinse sample was also collected from the respondent's right hand.

Alternatively, at every odd households (n=72), a water sample was taken after respondents were asked to clean their transport containers. Enumerators recorded what materials the respondents used to clean their transport containers and 50.9% used soap exclusively, 13.6% used gravel exclusively, 15.3% used both soap and gravel, while 20.3% used only water.

Water quality results

All water samples were analyzed for number of *E. coli* colonies/100 mL without any dilutions. The differences in *E. coli* concentrations at each stage of a household's drinking water supply chain can be seen in Figure 8. Of the household samples whose point source was a pump and had complete data, only 13.3% (95% CI 5.1%-21.5%) had safe water under the WHO guidelines of no detectable *E. coli* colonies/100 mL. However, 30.1% (95% CI 18.3%-41.8%) had high risk drinking water with >100 *E. coli* colonies/100 mL, 31.0% (95% CI 20.8%-41.1%) had intermediate risk drinking water with 11-100 *E. coli* colonies/100 mL, and 25.7% (95% CI 16.3%-35.0%) had low risk drinking water with 1-10 *E. coli* colonies/100 mL (Fig. 4).

For each of the two point sources in each village, the average of two water source samples was used to determine a single contamination level for each source. The majority of the point sources, 82.3% (95% CI 67.0%-97.6%, n=23), had no detectable *E. coli* colonies/100 mL while the remaining 6 sources had an average between 1-10 *E. coli* colonies/100 mL (Fig. 4). Like the source samples, the two transport samples' contamination levels were averaged to determine a single contamination value of transport containers for each of the identified sources in each village. There was a notable increase in contamination during the transportation stage in the water supply chain as 14.2% (95% CI 6.0%-22.4%) of transport containers had 11-100 *E. coli* colonies/100 mL, 53.1% were of low risk with 1-10 *E. coli* colonies/100 mL and only 32.7% (95% CI 23.1%-42.3%) had no detectable *E. coli* colonies/100 mL (Fig. 4). Figure 5 illustrates the observed increases in *E. coli* concentrations in the individual households' water supply chain from their point source to transport container to household drinking water.

Of the samples taken directly from the storage containers, only 18.2% (95% CI 9.4%-27.0%) of household's stored drinking water had no detectable *E. coli* colonies/100 mL, 21.8% (95% CI 11.4%-32.3%) were low risk drinking water, 34.6% (95% CI 21.1%-48.0%) had intermediate risk drinking water, and 25.5% (95% CI 13.4%-37.5%) had high risk drinking water with >100 *E. coli* colonies/100 mL (Fig. 4). For the hand rinse samples, 26.4% (95% CI 11.3%-41.5%) had no detectable *E. coli* colonies/100 mL, while all other respondents' hands had some degree of *E. coli* contamination (Fig. 4). Figure 6 illustrates the observed changes in *E. coli* concentrations in the individual households' water supply chain from their storage container to point-of-consumption drinking water, with the hand rinse sample representing an intermediary step in the supply chain.

Of the transport samples taken after having been cleaned by the respondent, about half, 48.3% (95% CI 30.8%-65.8%) had no detectable *E. coli* colonies/100 mL (Fig. 4).

As shown in Figure 7, 27.1% of the post-washing samples had no detectable *E. coli* colonies/100 mL and were cleaned with soap exclusively.

Factors associated with increased risk of household drinking water

In bivariate ordinal logistic regression analysis, factors that were associated with increasing the human health risk of household drinking water with p values <0.10 included: whether the storage container was stored inside or outside an enclosed structure in the household, how the drinking water was retrieved from the storage container, whether the storage container had a large or small mouth, and whether the storage container was open or closed (Table 2). Determinants not significantly associated were the use of an improved latrine, the type of storage container, whether the respondent touched the storage water upon retrieving the drinking water, the contamination level of the respondent's hand, the vessel the drinking water was served in, the location from where the drinking water vessel was retrieved, the type of transport container, age of the respondent, and number of kids under the age of 5 in the household.

Factors found to be significantly associated with an increased level of water contamination were subsequently included in a multivariate model, analyzed using ordinal logistic regression (Table 2). The odds of having higher concentrations of *E. coli* colonies in drinking water that was stored outside was 1.32 times that of the odds of drinking water stored inside (95% CI 0.59-2.92, p =0.49). Characteristics of the storage container, including the size of the mouth and whether it was open or closed, affected the odds of having higher levels of *E. coli* contamination. Storage containers with a large mouth had a protective effect (OR=0.38, 95% CI 0.08-1.76, p=0.21), as did storage containers that were closed (OR=0.61, 95% CI 0.26-1.46, p=0.27). Lastly, households where drinking water was scooped out of the storage container had an increased odds of having higher levels of *E. coli* contamination in their drinking water compared to households that poured water into the serving vessel (OR=1.28, 95% CI 0.29-5.61, p=0.74).

DISCUSSION

This is the first study assessing the fecal contamination of individual households' water supply chain in Burkina Faso. We found that the majority of household's drinking water did not meet WHO guidelines of no detectable *E. coli* colonies/100 mL which was consistent with other studies conducted in Burkina Faso (13, 14) and elsewhere (9, 11, 12). Additionally we found that the majority of the improved water sources, manual pumps, produced water that met WHO guidelines of no detectable *E. coli* colonies/100 mL. The findings of this study illustrate the need for interventions that inhibit the recontamination of drinking water where the water quality of the water sources has been improved.

While there was recontamination of drinking water during the transport stage of the water supply chain, a more substantial increase of fecal contamination of drinking water occurred between transporting the water and the point-of-consumption as shown in both Figures 4 and 5. The finding that there was an increase in the proportion of contaminated at this point in the water supply chain is consistent with the other studies conducted in Burkina Faso (13, 14) and elsewhere (9, 19, 29). However, the findings and visualization of the individual water supply chain contamination is novel. It is interesting to note that not only did the majority of the household samples have contamination levels that did not meet WHO quality standards, but the concentration of *E. coli* colonies were much more varied across the household samples compared to the transport samples as illustrated in Figure 5. This indicates that household level storage behaviors and risk factors have an individually unique influence on the recontamination of drinking water from the time the water arrives at the household to the point-of-consumption, while the factors that influence contamination during the transport stage are more uniform.

As shown in Figure 6, there was inconsistency between the contamination levels of the stored drinking water and the point-of-consumption drinking water with the fecal contamination present on the respondents' hands. Additionally, the respondent's hand contamination was not significantly associated with the household water quality in bivariate analysis. This finding is inconsistent with studies that found hand contamination to be associated with drinking water contamination (15, 17, 20). However, this disagreement could be potentially due to our study's low sample size or procedural error when taking the sample.

We found that half of the cleaned transport containers water samples had no detectable *E. coli* colonies (Fig. 4). We also found that half of the cleaned transport containers were cleaned using soap. However, of the cleaned transport only 27.1% of had no detectable *E. coli* colonies and were cleaned with soap exclusively (Fig. 7). The enumerators reported that many of the respondents used natural materials like gravel, peanut shells, and specific plant matter to clean their transport containers, sometime in conjunction with soap and sometimes without soap. These findings not only illustrate the importance of the need for better cleaning methods and materials to decontaminate the transport container in order to avoid recontamination at the transportation phase of the water supply chain but also illustrates the lack of knowledge on proper cleaning methods and the influence of culture as seen in the traditional means for washing containers.

Additionally, it may be assumed that the methods for washing the transport container do not vary significantly from the methods the respondent would use to wash the storage container. This signifies the importance of properly washing both containers as it may be hypothesized that the inefficiency of washing both containers may have a synergistic effect of the recontamination of the household's drinking water. This would be particularly true if households don't wash their storage container as often as their transport containers as clay pots were predominately used for storing drinking water (Table 1) (30).

Interestingly, none of the risk factors found to be significant in the bivariate model were significant in the multivariate model. The bivariate analysis found that storage containers that were stored inside the home, had a large opening, and were covered/enclosed had a protective effect against contamination, as is retrieving drinking water by pouring the water from the storage container directly into the drinking cup. These findings were consistent with other studies that considered these factors as predictors of household drinking water contamination (12, 19, 22, 31).

There are a number of limitations to this study. First, some of the households' data were not included in the analysis therefore our findings were underpowered and we were not able to fulfill our study's sample size goal. Therefore we cannot infer causality between the risk factors identified and drinking water contamination. Additionally, the timing of our study at the start of the rainy season, not only caused us to disrespect village selection randomization in one case, but also made the time points in which source samples were collected vary from village to village as well as the time between collection of water samples and time to analysis vary from village to village. Furthermore, the rainy season forced us to abandon random household sampling for convenience sampling. As the majority of our study's population are farmers, a large proportion of households were not at home during the time enumerators were at their village as they were in the fields.

It should also be noted that the transport container measurements were not truly representative of that point in the water supply chain for each household as the transport samples were collected from different villagers who happened to be collecting water at the time of sampling. While this was done in order to capture a true measurement of contamination at the transportation stage in general, it fails to directly represent the households enrolled in the study. Similarly, we did not have fully accurate quantitative measurements for water samples that yielded too many colonies to distinctively count and were subsequently given a level of 100 colonies/100 mL. While linear regression analysis would be the most appropriate for modeling water quality, due to the number of our study's samples with 100 colonies/100 mL, linear regression analysis was not able to be performed.

Other weaknesses of the study include deviations in sample collection methods and potential cross contamination of direct storage water samples due to the inconsistent use of a sterile cup by enumerators. Also, all water sample analyses were performed in a lab that required extensive travel as the study did not have the financial means or resources to use a mobile lab. Lack of funds also inhibited collecting direct storage samples, hand rinse samples, and post-washing transport container samples at each household, therefore, our findings were less robust.

Despite these limitations, this investigation describes the changes in the water quality at the various points along the water supply chain for rural households in Burkina Faso at an individual household level. These results enhance our understanding of where drinking water recontamination occurs along the water supply chain, highlights the importance of context specific WASH interventions, and can be utilized to inform WASH programming for CRS's intervention areas.

CONCLUSIONS AND RECOMMENDATIONS

Based on the study's findings, there are a number of potential interventions that could help ensure the microbiological quality of drinking water in this population. All except one of the participating village in this study had a functioning water pump that produced safe drinking water. Following the assumption that this population has access to an improved water source, a feasible and cost-effective intervention that would help reduce recontamination along the water supply chain is improved water containers, both storage and transport. This intervention has been proven to be effective in a culturally and geographically similar area (22). While there are other interventions that have proven to be more effective in case-control trials, the sustainability of these interventions that require behavioral change is weaker than that of an intervention such as improved water containers that are already culturally appropriate and where the behaviors are already in place (3, 32, 33).

Additionally, promoting treatment methods at point-of-use, such as point-of-use filtration systems and water disinfection products, are other impactful interventions in reducing the burden of diarrheal disease (9, 21, 29). I would argue that the point-of-use filtration systems would be more appropriate for the context of this study's population not only because point-of-use filtration systems are the more effective intervention, but because of the difficulty in uptake and sustainability associated with water disinfection products (3, 21, 22). As not all improved sources produce safe drinking water and since the burden of diarrheal disease is not uniform throughout these communities, more costly interventions should be implemented on the local level while more cost effective interventions on the community level (34).

The effectiveness of cleaning methods of transport and storage containers should also be investigated further. Future studies should look not only at the effectiveness of modern methods, like soap detergent and chlorine, but also consider the effectiveness of local materials like neem leaves and locally-made soaps. As interventions continue to promote the effectiveness of handwashing, we should be careful in propagating the principle that soap detergent and soap bars are adequate in disinfecting as the case may not be true in cleaning water storage containers (35).

Finally, the promotion of use of latrines and investment in the infrastructure of improved toilets in these communities should continue to be a priority. In this study, 40.7% of the households practiced open defecation. Furthermore, of those with latrines, a vast majority (76.6%) shared their latrine with other families. Improved sanitation has been associated with improved health outcomes, however this association is weaker when latrines are shared and open defecation is still practiced (3, 17, 21).

REFERENCES

1. Troeger, C., Forouzanfar, M., Rao, P. C., Khalil, I., Brown, A., Reiner, R. C., Jr., . . . Mokdad, A. H. Estimates of global, regional, and national mobidity, mortality, and aetiologies of diarrhoeal diseases: a systematic analysis for the Global Burden of Disease Study 2015. The Lancet Infectious Diseases, 17(9), 909-948. doi:10.1016/S1473-3099(17)30276-1
2. Baker, K. K., O'Reilly, C. E., Levine, M. M., Kotloff, K. L., Nataro, J. P., Ayers, T. L., . . . Mintz, E. D. (2016). Sanitation and Hygiene-Specific Risk Factors for Moderate-to-Severe Diarrhea in Young Children in the Global Enteric Multicenter Study, 2007–2011: Case-Control Study. PLOS Medicine, 13(5). doi:10.1371/journal.pmed.1002010
3. Hutton, G., & Chase, C. (2016). The Knowledge Base for Achieving the Sustainable Development Goal Targets on Water Supply, Sanitation and Hygiene. International Journal of Environmental Research and Public Health,13(12), 536. doi:10.3390/ijerph13060536
4. WHO. Burkina Faso Health Profile. Retrieved from http://www.who.int/gho/countries/bfa.pdf?ua=1
5. Bonkoungou, I. J. O., Haukka, K., Österblad, M., Hakanen, A. J., Traoré, A. S., Barro, N., & Siitonen, A. (2013). Bacterial and viral etiology of childhood diarrhea in Ouagadougou, Burkina Faso. BMC Pediatrics, 13(1), 36. doi:10.1186/1471-2431-13-36
6. University of Maryland School of Medicine (2018). *The Global Enteric Mulitcenter Study: Bamako, Mali.* [Fact sheet]. Retrieved from

http://www.medschool.umaryland.edu/media/SOM/Z-MIGRATION-/Migration---Nov-13-165323/Research-Centers/Center-for-Vaccine-Development-CVD/Global-Enterics-Multi-Center-Study-GEMS/docs/Mali-ENGLISH-Supplemental-Fact-Sheet.pdf

7. Centers for Disease Control and Prevention (2018). *E.coli (Esterichia coli)*. Retrieved from https://www.cdc.gov/ecoli/general/index.html
8. Centers for Disease Control and Prevention (2018). Drinking Water. Retrieved from https://www.cdc.gov/healthywater/drinking/private/wells/disease/cryptosporidium.html
9. Wright J, Gundry S, Conroy (2004). Household drinking water in developing countries: a systematic review of microbiological contamination between source and point-of-use. *Trop. Med. & Int'l Health* 9(1):106-17.
10. Trevett, A. F., Carter, R. C., & Tyrrel, S. F. (2005). Mechanisms leading to post - supply water quality deterioration in rural Honduran communities. *International Journal of Hygiene and Environmental Health, 208*(3), 153-161. doi:10.1016/j.ijheh.2005.01.024
11. Clasen, T. F., & Bastable, A. (2003). Faecal contamination of drinking water during collection and household storage: the need to extend protection to the point of use. J Water Health, 1(3), 109-115.
12. Kirby, M. A., Nagel, C. L., Rosa, G., Iyakaremye, L., Zambrano, L. D., & Clasen, T. F. (2016). Faecal contamination of household drinking water in Rwanda: A

national cross-sectional study. Science of The Total Environment, 571, 426-434. doi:10.1016/j.scitotenv.2016.06.226

13. Lalanne, F., (2012). Etude de la qualité de l'eau le long de la chaîne d'approvisionnement au niveau des consommateurs dans 10 villages de la Province du Ganzourgou, Région du Plateau Central au Burkina Faso. 2iE Foundation.
14. Catholic Relief Services. (2016). Rapport d'analyse microbiologique des eaux de boissons de 10 ecoles du Projet Kom Yilma.
15. Pickering, A. J., Davis, J., Walters, S. P., Horak, H. M., Keymer, D. P., Mushi, D., . . . Boehm, A. B. (2010). Hands, Water, and Health: Fecal Contamination in Tanzanian Communities with Improved, Non-Networked Water Supplies. Environmental Science & Technology, 44(9), 3267-3272. doi:10.1021/es903524m
16. Curtis, V., Cousens, S., Mertens, T., Traore, E., Kanki, B., & Diallo, I. (1993). Structured observations of hygiene behaviours in Burkina Faso: validity, variability, and utility. *Bulletin of the World Health Organization, 71*(1), 23–32.
17. Wang, Y., Moe, C. L., Null, C., Raj, S. J., Baker, K. K., Robb, K. A., . . . Teunis, P. F. M. (2017). Multipathway Quantitative Assessment of Exposure to Fecal Contamination for Young Children in Low-Income Urban Environments in Accra, Ghana: The SaniPath Analytical Approach. *The American Journal of Tropical Medicine and Hygiene, 97*(4), 1009-1019. doi:doi:https://doi.org/10.4269/ajtmh.16-0408

18. Fewtrell, L., Kaufmann, R. B., Kay, D., Enanoria, W., Haller, L., & Colford, J. M. (2005). Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta-analysis. *The Lancet Infectious Diseases, 5*(1), 42-52. doi:https://doi.org/10.1016/S1473-3099(04)01253-8
19. Rufener, S., Mausezahl, D., Mosler, H. J., & Weingartner, R. (2010). Quality of drinking-water at source and point-of-consumption--drinking cup as a high potential recontamination risk: a field study in Bolivia. J Health Popul Nutr, 28(1), 34-41.
20. Mattioli, M. C., Boehm, A. B., Davis, J., Harris, A. R., Mrisho, M., & Pickering, A. J. (2014). Enteric Pathogens in Stored Drinking Water and on Caregiver's Hands in Tanzanian Households with and without Reported Cases of Child Diarrhea. PLoS ONE, 9(1). doi:10.1371/journal.pone.0084939
21. Clasen, T., Roberts, I., Rabie, T., & Cairncross, S. (2004). Interventions to improve water quality for preventing diarrhoea. Cochrane Database of Systematic Reviews. doi:10.1002/14651858.cd004794
22. Günther, I., & Schipper, Y. (2012). Pumps, Germs And Storage: The Impact Of Improved Water Containers On Water Quality And Health. Health Economics, 22(7), 757-774. doi:10.1002/hec.2852
23. Gruber, J. S., Ercumen, A., & Colford, J. M. (2014). Coliform Bacteria as Indicators of Diarrheal Risk in Household Drinking Water: Systematic Review and Meta-Analysis. PLoS ONE, 9(9). doi:10.1371/journal.pone.0107429

24. Luby, S. P., Johnston, R. B., Unicomb, L., Islam, M. S., Halder, A. K., Huda, T. M., & Arnold, B. F. (2015). Microbiological Contamination of Drinking Water Associated with Subsequent Child Diarrhea. The American Journal of Tropical Medicine and Hygiene, 93(5), 904-911. doi:10.4269/ajtmh.15-0274

25. Hodge, J., Chang, H. H., Boisson, S., Collin, S. M., Peletz, R., & Clasen, T. (2016). Assessing the Association between Thermotolerant Coliforms in Drinking Water and Diarrhea: An Analysis of Individual–Level Data from Multiple Studies. Environmental Health Perspectives, 124(10). doi:10.1289/ehp156

26. World Health Organization (WHO). Guidelines for drinking water quality. 4th ed. WHO, Geneva, Switzerland; 2011

27. Vanderslice, J., & Briscoe, J. (1993). All coliforms are not created equal: A comparison of the effects of water source and in-house water contamination on infantile diarrheal disease. Water Resources Research, 29(7), 1983-1995. doi:10.1029/92wr02994

28. Robb, K., Null, C., Teunis, P., Yakubu, H., Armah, G., & Moe, C. L. (2017). Assessment of Fecal Exposure Pathways in Low-Income Urban Neighborhoods in Accra, Ghana: Rationale, Design, Methods, and Key Findings of the SaniPath Study. *The American Journal of Tropical Medicine and Hygiene, 97*(4), 1020-1032. doi:doi:https://doi.org/10.4269/ajtmh.16-0508

29. Gundry, S. W., Wright, J. A., Conroy, R., Du Preez, M., Genthe, B., Moyo, S., . . . Potgieter, N. (2006). Contamination of drinking water between source and point-of-use in rural households of South Africa and Zimbabwe: implications for

monitoring the Millennium Development Goal for water. *Water Practice and Technology, 1*(2). doi:10.2166/wpt.2006.032

30. Stocker, A., & Mosler, H. (2015). Contextual and sociopsychological factors in predicting habitual cleaning of water storage containers in rural Benin. Water Resources Research, 51(4), 2000-2008. doi:10.1002/2014wr016005

31. Harris, A. R., Davis, J., & Boehm, A. B. (2013). Mechanisms of post-supply contamination of drinking water in Bagamoyo, Tanzania. Journal of Water and Health, 11(3), 543. doi:10.2166/wh.2013.023

32. Curtis, V., Cairncross, S., & Yonli, R. (2000). Review: Domestic hygiene and diarrhoea - pinpointing the problem. Tropical Medicine and International Health, 5(1), 22-32. doi:10.1046/j.1365-3156.2000.00512.x

33. Davis, J., Rogers, K., Boehm, A. B., Mamuya, S., & Pickering, A. J. (2011). The Effects of Informational Interventions on Household Water Management, Hygiene Behaviors, Stored Drinking Water Quality, and Hand Contamination in Peri-Urban Tanzania. The American Journal of Tropical Medicine and Hygiene, 84(2), 184-191. doi:10.4269/ajtmh.2011.10-0126

34. Bado, A. R., Susuman, A. S., & Nebie, E. I. (2016). Trends and risk factors for childhood diarrhea in sub-Saharan countries (1990–2013): Assessing the neighborhood inequalities. Global Health Action, 9(1), 30166. doi:10.3402/gha.v9.30166

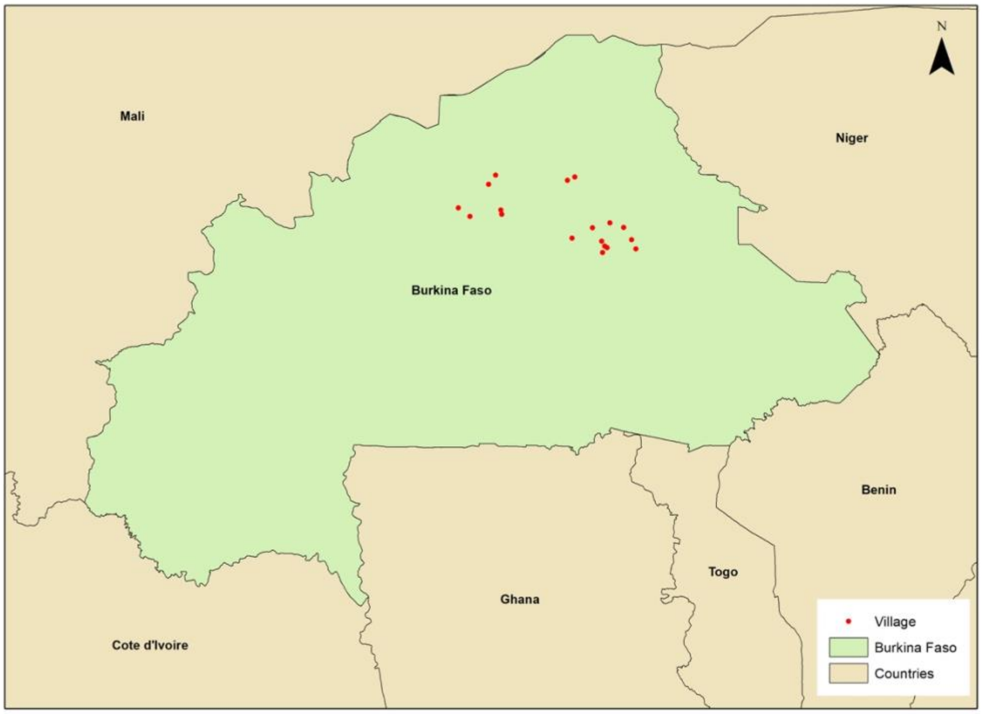
35. Amin, N., Islam, M. S., Homaira, N., Najnin, N., Abedin, J., Ashraf, S., . . . Ram, P. K. (2014). Microbiological Evaluation of the Efficacy of Soapy Water to Clean

Hands: A Randomized, Non-Inferiority Field Trial. The American Journal of Tropical Medicine and Hygiene, 91(2), 415-423. doi:10.4269/ajtmh.13-0475

FIGURES

Figure 1: Maps of Participating Villages

Participating Villages, Burkina Faso, 2017



Participating Villages, Burkina Faso, 2017

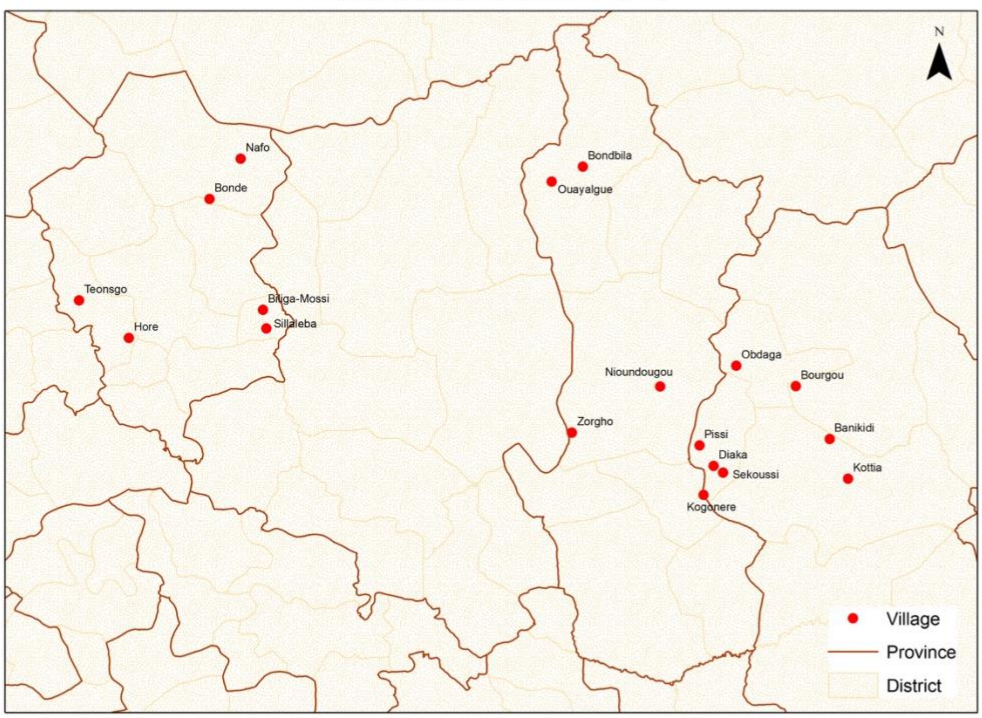


Figure 2:

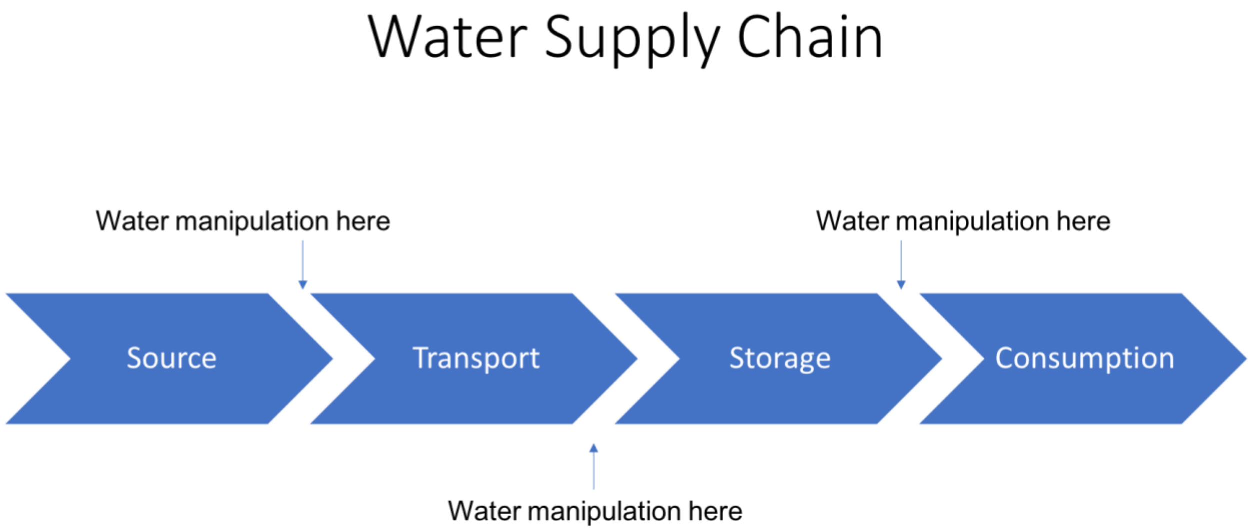


Figure 3: Sampling Strategy Schematic

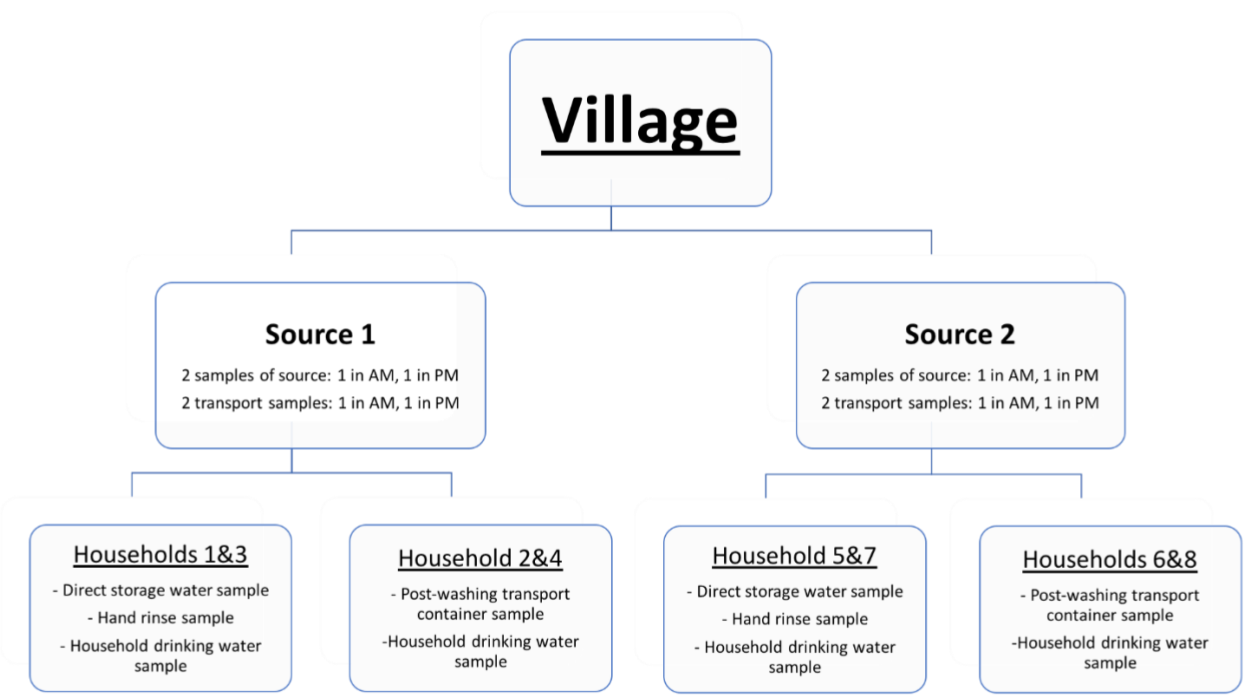


Figure 4: The proportion of samples along the water supply chain with varying levels of *E. coli* concentrations with 95% confidence intervals

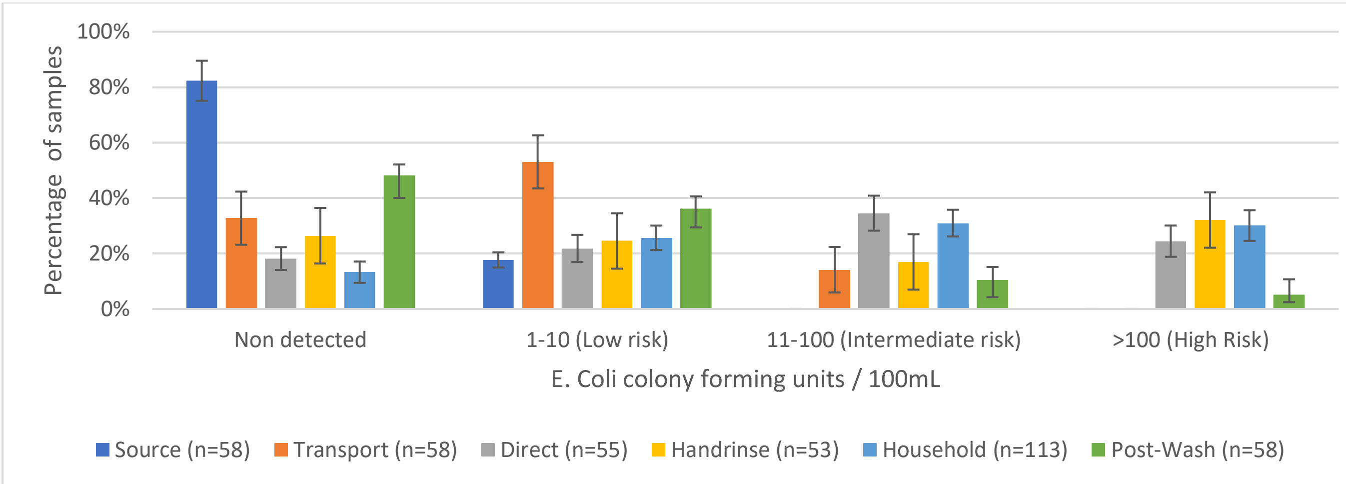


Figure 5: Increases of *E. coli* concentrations along the water supply chain by household

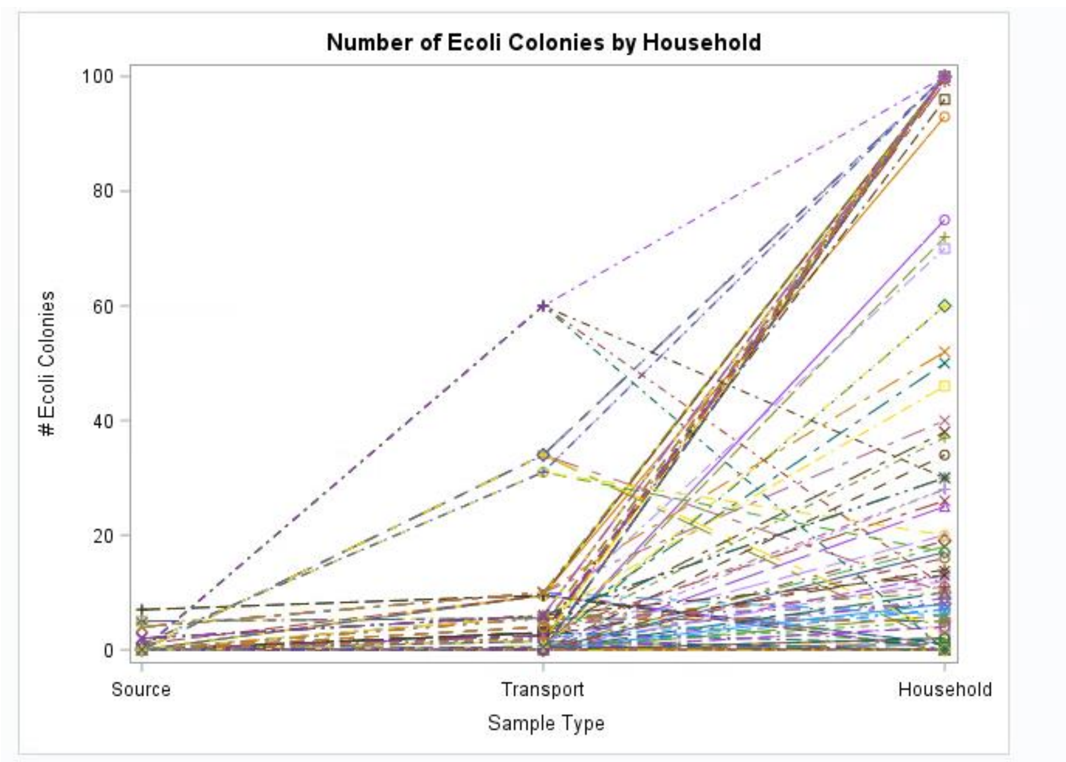


Figure 6: Changes in *E. coli* concentrations from the sample types: Storage Container, Hand Rinse, and Point of Consumption

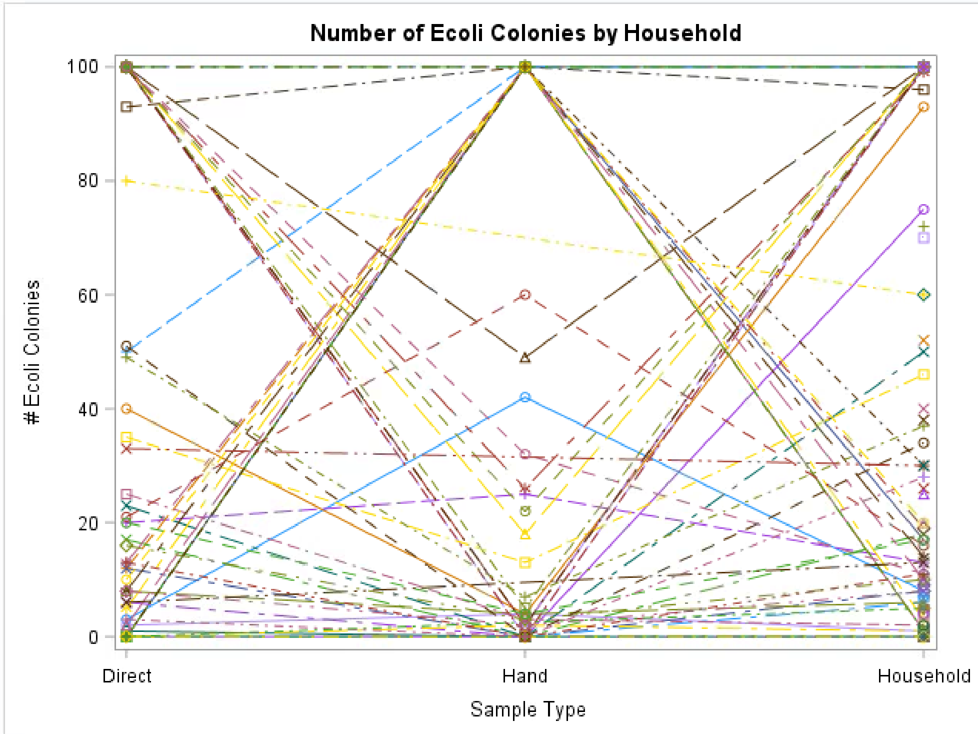


Figure 7: *E. coli* concentration for post wash samples by the materials used during the washing process

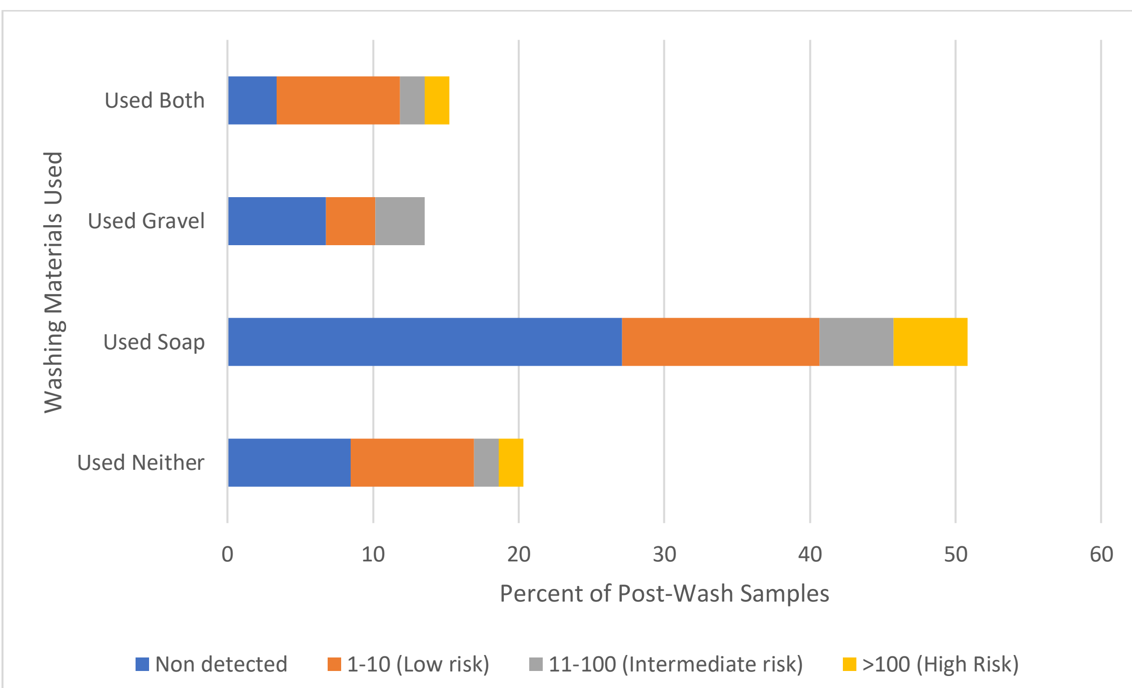
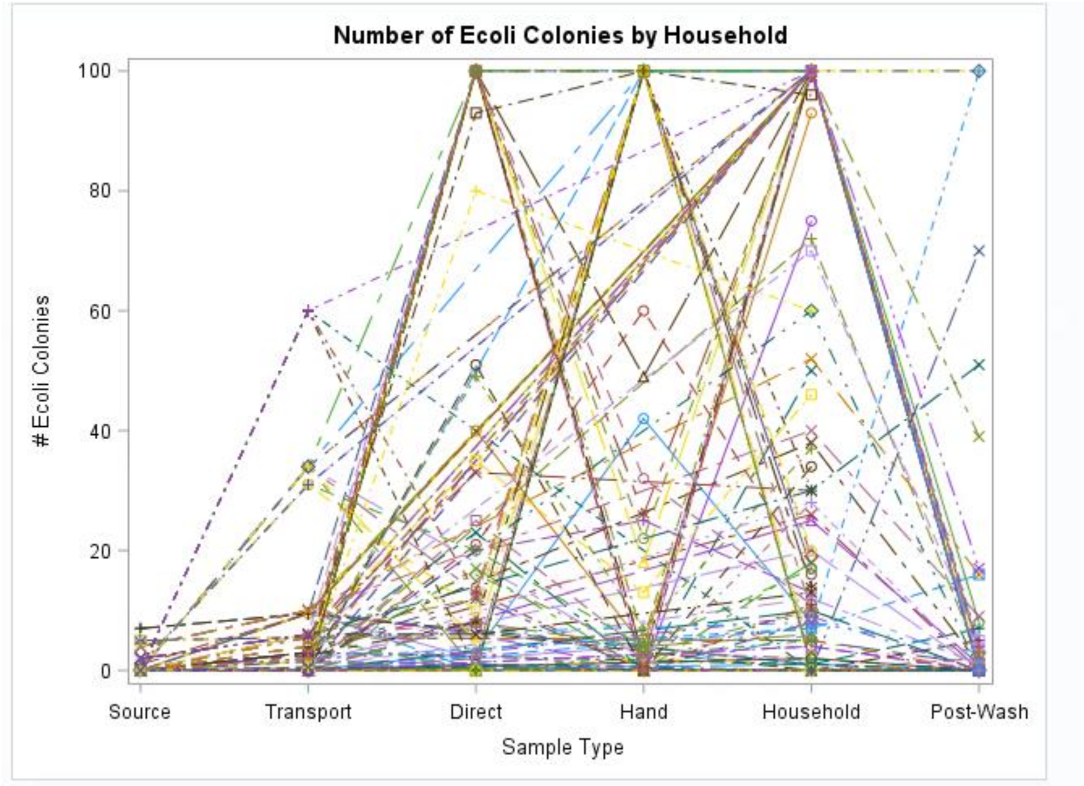


Figure 8: Changes in *E. coli* concentrations of the different samples taken for each household



TABLES

Table 1: Characteristics of participating households, n=113*

Household Characteristics	
Female, n (%)	111 (98.2)
Age; Mean (SD)	28.9 (11.1)
Household Size; Mean (SD)	8.5 (4.1)
Children under 5; Mean (SD)	1.8 (1.2)
Husband Not Educated; n (%)	90 (79.6)
Primary Source of Income; n (%)	
Farming	95 (85.6)
Mining	5 (4.5)
Other	11 (9.9)
Owns a Motorcycle; n (%)	59 (52.2)
One or more farm animals sleep in courtyard; n (%)	113 (100)
Latrine Characteristics	
Latrine Type; n (%)	
Pit Latrine with slab	56 (49.6)
Pit latrine without slab	3 (2.7)
Ventilated pit	8 (7.1)
No Latrine	46 (40.7)
Shared Latrine; n (%)	49 (76.6)
Handwashing Characteristics	
Frequency of Handwashing in 24 hrs; Mean (SD)	7.8 (4.4)
Washes Hands with Soap; n (%)	91 (80.5)
Has Dedicated Hand Washing Location; n (%)	13 (11.5)
Water Container Characteristics	
Clay Pot Storage Container; n (%)	72 (63.7)
Plastic Jug Transport Container; n (%)	103 (91.2)

Table 2: Bivariate and Multivariate ordinal logistic model for no detectable E.coli/100 mL vs 1-10 E.coli/100 mL vs 11-99 E.coli/100 mL vs >=100 E.coli/100 mL

	Bivariate Model			Multivariate Model		
	OR (95% CI)		*p* value	OR (95% CI)		*p* value
Storage container inside	**REF**			**REF**		
Storage container outside	1.83	(0.90-3.72)	0.09	1.32	(0.59-2.92)	0.49
Poured water into serving vessel	**REF**			**REF**		
Scooped water using serving vessel	2.16	(1.09-4.27)	0.03	1.28	(0.29-5.61)	0.74
Storage Container; small mouth	**REF**			**REF**		
Storage Container; big mouth	0.39	(0.19-0.82)	0.01	0.38	(0.08-1.76)	0.21
Storage Container Open	**REF**			**REF**		
Storage Container Closed	0.44	(0.21-0.95)	0.04	0.61	(0.26-1.46)	0.27

APPENDIX: Survey Tools

Section A: caractéristiques socio-démographique du ménage
Ce questionnaire sera sur support électronique (utilisation de Ipad, Smartphone), cependant les questions et les réponses proposées seront transcrites exactement comme présentées ci-après même ci les formats seront présentés différemment.

référence de la question	*Question à poser au répondant*	*Réponse à sélectionner*
Q1	Nom de l'enquêteur [Une seule réponse est possible]	1. 2. 3.
Q2	Lui avez-vous lu le formulaire de consentement? Did you read the consent statement?	1.Oui 2.Non
Q3	Ont-ils accepté de participer?	1.Oui 2.Non ⇒ Aller a la fin
Q4	Ont-il signé le formulaire de consentement?	1.Oui 2.Non
Q5	Leur avez-vous donné une copie du formulaire de consentement?	1.Oui 2.Non
	Information d'ordre générale:	
Q6	Emplacement du village:	1. 2. 3.
Q7	Numéro d'identification du ménage: *Indication: les initiales de l'enquêteur plus le numéro complet du ménage ex. MR001* [Seulement une longueur de 5 caractères. A completer	__ __ __ __ __
Q8	Nom du chef de ménage?	
Q9	Sexe (du chef de ménage)?	1.Male 2.Femelle
~~Q10~~	~~Quelle est la religion de (nom du chef de ménage)?~~	~~1.Chrétien~~ ~~2.Musulman~~ ~~3.Animiste~~ ~~4.Autre ___________~~
~~Q11~~	~~Quelle est l'ethnie du (Nom du chef de ménage)?~~	~~1.Mossi~~ ~~2.Peulh~~ ~~3. Gourmantché~~ ~~4.Other _________~~
Q12	Est-ce que (Nom du chef de ménage) a fréquenté?	1.Oui 2.Non
Q13	Quel niveau de scolarisation avez-vous attaint?	1 Primaire 2 Secondaire 3 plus élevé 4 Ne sais pas
Q14	Sexe du répondant of respondent *(cocher le cas correspondnat, ne pas demander)*	1.Male 2.Femelle
Q15	Nom du répondant:	
Q16	Quel est votre lien de parenté avec le chef de ménage	1. Head 2.Femme 3. Fille

		4. SFils 5. Aide ménagère 6. Grand père 7. Grand mère 8.Autre (préciser) ________
Q17	Quelle est votre religion de?	1.Chrétien 2.Musulman 3.Animiste 4.Autre __________
Q18	Quelle est votre ethnie?	1.Mossi 2.Peulh 3. Gourmantché 4.Other _________
Q19	Combien de personnes vivent dans ce ménage?	
Q20	Combien d'enfants de moins de 5 ans ya t-il? *Précision: 0 a 4 ans* [02 caractères seulement sont possibles]	
Q21	Combien d'enfants ont un age compris entre 5 et 16 ans? [02 caractères seulement sont possibles]	
Q22	Combien ont un age supérieur a 16 ans? *Precision: cela signifie au moins 17 ans* [02 caractères seulement sont possibles]	
Q23	Quelle est la source de revenue principale de votre ménage?	1. Professionnelle/Technique/Gestionnaire 2. Clerical 3. Ventes et services 4. Main d'oeuvre qualifiée 5. Main d'oeuvre non qualifiée 6. Service Domestique 7. Propre production agricole 8. Elevage 9. Autre (spécifier)________
Q24	Est-ce que votre ménage a: une Radio?	1.Oui 2.Non
Q25	Est-ce que votre ménage a: Télévision?	1.Oui
Q26	Est-ce que votre ménage a: téléphone cellulaire?	2.Non
Q27	Est-ce que votre ménage possède une Moto?	1.Oui
Q28	Est-ce que votre ménage possède une terre agricole?	2.Non
Q29	Est-ce que votre ménage possède des animaux de fermes?	1.Oui 2.Non ⇒ aller a la question 34
Q30	Combien de boeufs?	
Q31	Combien de chèvres/moutons?	
Q32	Combien de poulets?	
Q33	Combien d'autres animaux possedez vous? *Suggestion: porcs, lapins, chiens, anes, etc.*	
Q34	Est-ce que votre ménage a l'électricité??	1.Oui 2.Non
Q35	Type de revêtement du sol	1. sol naturel terre/sable earth/sand

	Observation *from enumerator, do not ask question. Note MOST prevalent* *Observation a faire par l'enquêteur, ne pas poser de question.* *Note: considérer le revêtement le plus utilisé*	2. Fumier 3. Planches de bois 5. Carreaux 6. Ciment 8. Autre
Q36	Type de matériaux pour les murs *Observation a faire par l'enquêteur, ne pas poser de question.* *Note: considérer le plus répandu*	Pas de murs briques en terre - non revêtues- briques en terre - revêtus de terre briques en terre – revêtues de ciment parpaings – non revêtus parpaings – revêtus de ciment Autre
Q37	Combien de chambres ya-il dans votre maison? How may rooms are there in your home? *Precision: inclure la cuisine et le magasin* [seul 2 caracteres maximum sont possibles]	__________
Q38	Combien de chambre la maison a-telle ?	1. Une 2. Deux 3. Trois ou plus

Section B: Assainissement et hygiène du ménage

Q39	16. Quel type de latrine les membres de votre ménage utilisent-ils habituellement?	1. Latrine a fosse avec une dalle 2. Latrine a fosse sans dalle/fosse ouverte 3. latrine type VIP 4. Pas de latrine ou brousse/plein air 5. Autre
Q40	Pouvez-vous me montrer votre latrine?	1.Oui 2.Non, permission non accordée ⇒ Aller à la question 42
Q41	**OBSERVER:** confirmation de l'existence de la latrine que le ménage utiliserait	1. Oui 2. Non
		Notes sur la latrine:
Q42	Partagez vous votre latrine avec d'autres ménages?	1.Oui 2.Non
Q43	Depuis hier matin/soir jusqu'à ce matin/soir combine de fois avez vous lave vos mains?	Nombre de fois: __
Q44	***Hint: Only ask if washed hand 1 or more times*** A quelles occasions avez-vous lave vos mains?	

Q45	Qu'est-ce vous utilisez habituellement pour vous laver les mains? [Do no prompt]	1. avec de l'eau seulement 2. Avec de l'eau et du savon 3. Autre, _____________
Q46	Avez-vous un endroit spécifique ou vous vous lavez les mains après défécation??	1.Oui 2.Non ⇒ Aller à la question 51
Q47	Pouvez-vous me montrer cet endroit?	1.Oui 2.Non, pas permis ⇒ Aller à la question 51
Q48	**OBSERVER:** Ya t-il de l'eau disponible pour le lavage des mains?	1. Oui 2. Non
Q49	**OBSERVER:** Ya-il du savon ou du détergent ou de la cendre?	1. Oui, savon ou détergent 2. Oui, cendre 3. Non
Q50	**OBSERVER:** Ya t-il un receptacle (plat, seau) qui est utilisé pour le lavage des mains?	1. Oui 2. Non

Section C: Water Consumption/Treatment

Q51	Quelle est la principale source d'approvisonnement en eau de boisson? [Seule une reponse est à choisir]	1. Source 2. Rivière 3. Puits ouvert 4. Puits fermé 5. Collecte d'eau de pluie 6. borne fontaine publique 8. Robinet familial 9. Robinet d'un ménage voisin 10. Lac 11. Barrage 12. Eau courante à la suite de pluie 13. Autre (préciser) ________ **Si la source est privée, prière le préciser**
Q52	**Localisation de la source**	Détails précisant la localisation:
Q53	Combien de temps en moyenne faut-il pour aller a la source, obtenir l'eau et revenir de la source que vous frequentez pendant la saison	Nombre de minutes _______ Non Applicale (pour ceux qui ont l'eau sur place)
Q54	Quel type d'ustensile utilisez vous pour recuperer l'eau	1.bidon 2.gros plats 3. Autre
Q55	Lavez-vous ces ustensiles de collecte	1.Oui Si Oui, Quand?________ A quelle fréquence,___________ Comment?___________ 2. Non
Q56	**OBSERVER**: Demander à voir l'ustensile :	1.Oui…Décrire_________ 2.Non

	Est-ce que l'ustensile se ferme correctement? Demander à prendre une photo	
Q57	Combien de bidons amenez-vous par voyage?	
Q58	Comment transportez vous l'eau de la source à la maison?	1.sur la tête 2.avec un velo 3.avec une charrete asine 4. à moto 5.Autre__________
Q59	Qui se charge de la corvée d'eau?	1.Les enfants 2.le Repondant 3.les femmes 4.les hommes 5. Autre_____
Q60	L'eau transportée est-elle mise dans un autre récipient pour le stockage?	1.Oui Si Oui, comment? Si Oui, quel autre récipient est utilisé? Si Oui, Quand? 2.Non (aller à la question 62)
Q61	Quel type de récipient est utilisé pour le stocker de l'eau de boisson?	1.bidon 2. gros plat 3. Autre_____
Q62	Est-ce que l'eau de boisson est stockée séparément de l'eau utilisée pour les autres usages?	1.Oui 2.Non
Q63	Combien de bidons d'eau sont utilisés pour la boisson par jour? Seulement pour la boisson Quel est le volume des bidons utilisés pour l'eau de boisson?	1. 1 bidon volume ______ 2. 2 bidon volume ______ 3. 3 bidon volume ______ 4. 4 bidon volume ______ 5. 5 bidon volume ______ Autre____________________
Q64	Si un enfant de moins de 5 ans veut de l'eau pour boire en ce moment precis, où prendrez-vous de l'eau pour lui? Pouvez-vous me montrer où? Demander à prendre une photo	1.Oui 2.Non ⇒ Aller à la question 78 3.Pas d'eau dans la maison⇒ aller à la question 78
Q65	**OBSERVER: Est-ce que le ménage stocke l'eau** à **l'intérieur de la maison**? *Rappel: Ne pas demander, observer seulement et noter*	1. Oui 2.Non, itilise directement un robinet ⇒ aller à la question 78 3.Non, demande l'eau aux voisins⇒ aller à la question 78
Q66	quel type de récipient utilisent-ils pour stocker l'eau de boisson? *<u>Avec une sortie/bec étroit</u> = la sortie/le bec est si étroit que la main d'un enfant ne peut pas y entrer.*	1.bec/sortie étroite 2.bec/sortie large
Q67	Est-ce que le récipient de stockage est couvert?	1.Oui 2.Non ⇒ Aller à la question 69
Q68	Qu'est-ce qui est utilisé pour couvrir le récipient de stockage?	1.Couvercle bien adapté/serré 2.Plat 3. Autre ______________

Q69	Comment vous servez-vous l'eau de boisson? Pouvez-vous me montrer?	1. utilise un robinet 2. verse l'eau 3. Tasse/récipient plongé dans l'eau 4. Utilise une louche 5. Autre__________________
Q70	Puis-je prendre un echantillon d'eau? – confirmer la prise de l'échantillon d'eau	1.Oui 2.Non
Q71	Avez-vous fait quelque chose pour rendre cette eau sure/potable pour la boisson?	1.Oui 2.Non ⇒ Aller à la question 77
Q72	Si oui, qu'avez vous fait?	1. eau bouillie 2. Traite avec un produit (chloration) 3. Filtration 4. Eau achetée 5. Laisser reposer avant 6. Autre (préciser) ________
Q73	Est-ce que le ménage a des produits de traitement dans la maison?	1.Oui 2.Non ⇒ Aller à la question 77
Q74	M'autorisez vous à prendre une photo? *Prendre une photo de la method de traitement ex: filter, bouteille, sachet ou pot et poêle*	1.Oui 2.Non
Q75	A quell frequence traitez-vous votre eau de boisson?	1.chaque jour 2.une fois par semaine 3.deux à trois fois par semaine 4.Autre
Q76	Combien de litres d'eau traitez-vous à chaque fois que vous traitez l'eau?	___
Q77	Puis-je prendre un échantillon d'eau de rincage de main?	1.Oui 2.Non
Q78	Prendre Coordonnées GPS du ménage	
Q79	Avez-vous pu prendre les coordonnées GPS du ménage?	1.Oui 2.Non
Q80	Heure de fin de l'interview: (hh:mm)	|_|_|/|_|_| (24HH)

LIRE CE QUI SUIT: "Merci encore d'avoir consacré votre temps à aider à compléter ce sondage. Vos réponses sont grandement appréciées"
."

EndHeure de fin de l'interview: _ _ : _ _
HH:MM